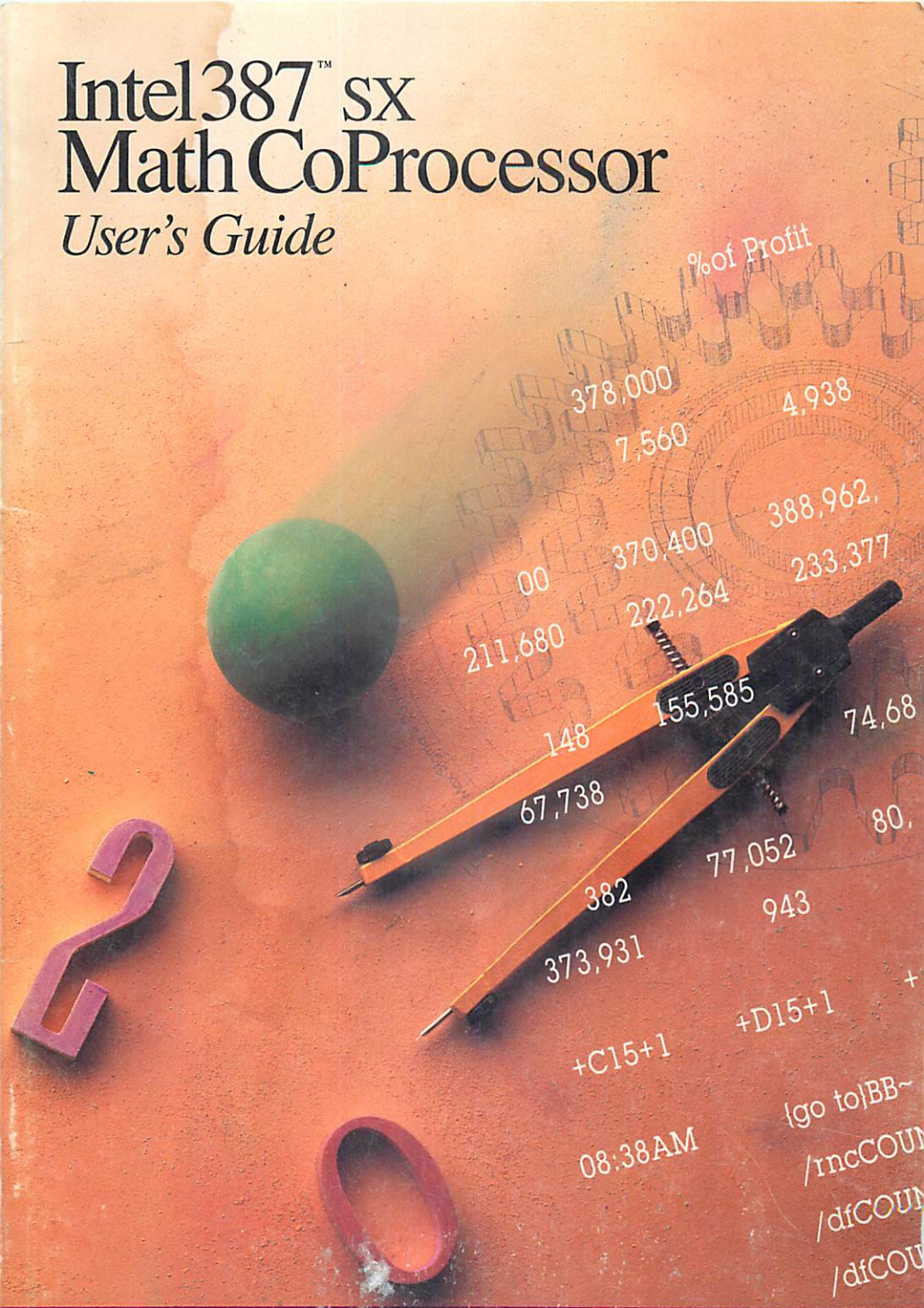
# Intel387™ SX Math CoProcessor

*User's Guide*

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| First Edition | April 1987 | Fourth Edition | January 1991 |
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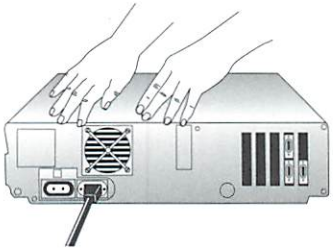
## Quick Installation Guide

**The Intel Math CoProcessor Utilities diskette included with your math coprocessor provides an animated installation demonstration. You may wish to run it before proceeding. Refer to the diskette label for instructions.**

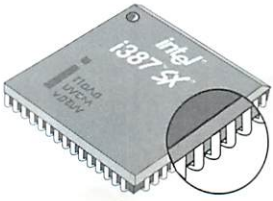
This Quick Guide is for customers who are familiar with installing desktop computer upgrade products; other customers should use the more detailed instructions in this manual. *If you own a "laptop" computer, check your computer user's manual or contact your dealer before attempting installation. Special tools and procedures may be required.*

**Step 1: Remove the cover from your computer. Be sure to ground yourself.**

***Warning! Danger to you! Turn off the computer's power switch and unplug the power cord from the wall outlet. If you don't you could electrocute yourself.***

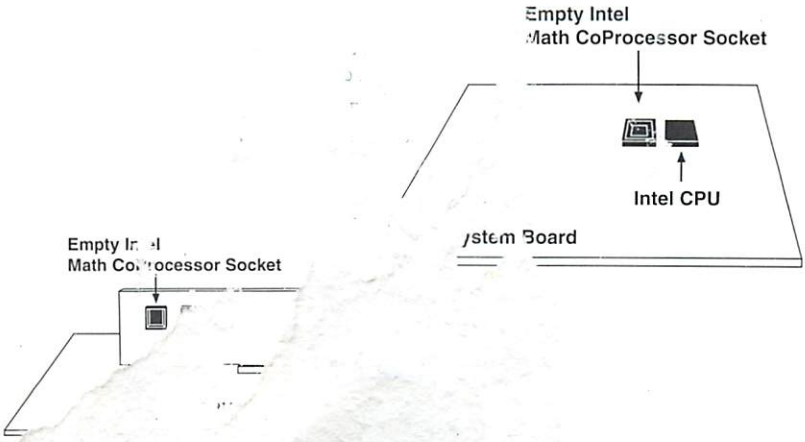


**Step 2: Examine the curved pins.**
If any of the curved pins are damaged, return the Intel387 SX Math CoProcessor to your dealer. Do not try to repair any damaged curved pins. Minimize contact with the curved pins as much as possible.

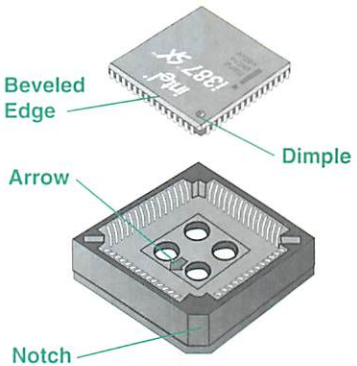


Curved Pins

**Step 3: Find the math coprocessor socket.** Check your system board or CPU card to find the math coprocessor socket.



**Step 4: Orient your math coprocessor correctly.** To orient the Intel387 SX chip correctly, you'll need to know which corner of the socket has pin 1. The Intel387 SX Math CoProcessor has a dot marking the pin 1 corner. It also has a slightly beveled edge along one side of the chip (see illustration). Some sockets label pin 1 with a notch, bevel, dot, arrow, or other mark. Place the chip into the socket as shown here.




**Step 5: Insert your math coprocessor in the empty socket.**
*Note that the loop connectors should face into the socket and the Intel logo should face out.* Press firmly on the Intel387 SX Math CoProcessor to "seat" it in the socket.

**Step 6: Set switches on the system board.**
You may need to set switches, jumpers, or both on your computer's system board to let the computer know you've added a math coprocessor. Refer to your computer user's manual for information.

**Step 7: Put the cover back on the system unit.** Reconnect all the cables and cords, and plug the power cord into the wall outlet. Turn on the computer. If your computer requires it, run the computer's setup or configuration program.

If you have problems with your computer after installing the math coprocessor, see *Troubleshooting* in the User's Guide.

**Step 8: Test your math coprocessor.** If you already installed the utilities to view the animated installation, type **rt mcp** at the DOS prompt. When the main menu appears, select "Advanced Diagnostics" to test your math coprocessor. If you have not installed the utilities, insert the utilities diskette in drive A and type:

**A:** and press Enter
then type **install** and press Enter

Follow the directions on the screen after installation is complete.

# Introduction

Congratulations on your purchase of an Intel387 SX Math CoProcessor!

You have joined over nine million other computer users who benefit from the extra performance gained by installing an Intel Math CoProcessor.

On most desktop computers, your math coprocessor is easy to install and use. Simply refer to your owner's manual and this manual for instructions. Because of their small size and high degree of integration, laptop and portable computers may need special tools and procedures for math coprocessor installation. Contact your laptop computer dealer or manufacturer for specific instructions for your particular laptop model.

Once your Intel387 SX has been installed, no additional software is needed. Your Intel387 SX Math CoProcessor Utilities diskette shows an animated installation demonstration that applies to most desktop computers. To view this demo, insert the diskette in drive A and type:

**A:** and press **Enter**
then type **install** and press **Enter**
Follow the instructions on your screen after the program installs.

Because your Intel387 SX Math CoProcessor is made by the same people who designed the Intel386 SX microprocessor, it is 100% compatible with your Intel386 SX computer and PC software. Most of your favorite programs will run faster.

The following list contains just a few of the many programs that use the math coprocessor's speed.

- **Business graphics programs** such as Arts and Letters, Freedom of Press, and Freelance.
- **Spreadsheet programs** such as Lotus 1-2-3, Excel, Quattro, and Wingz.
- **Computer Aided Design (CAD) programs** such as AutoCAD, IBM CAD, VersaCAD, and Generic CADD.
- **Database programs** such as dBase IV, FoxBase, and Paradox.
- **Math and Science programs** such as Mathematica, TK Solver, SPSS/PC and Statgraphics.

These programs and more than 21 others can gain speed when used with an Intel Math CoProcessor.

**Plus, you get genuine Intel quality and an industry-leading warranty.**

# Programs that use the Intel387 SX Math CoProcessor

This section contains a short list of programs that run faster when an Intel Math CoProcessor is present in the computer. This list represents only a small portion of the programs actually available. Currently over 2100 programs use or require a math coprocessor. For a complete list of these programs, call the Intel literature department at 800-548-4725 and ask for the Intel Math CoProcessor Product Guide (part number 296523). If you live outside the U.S.A. and Canada, call your local Intel sales office.

| Program | Company | Status* | Telephone |
|---|---|---|---|
| **Spreadsheet Programs** | | | |
| 1-2-3 | Lotus Development Corp. | S | 617-577-8500 |
| Lucid 3-D | Dac Software, Inc. | S | 214-248-0205 |
| Microsoft Excel | Microsoft Corp. | S | 206-882-8080 |
| Microsoft Multiplan | Microsoft Corp. | S | 800-426-9400 |
| QUATTRO | Borland International, Inc. | S | 408-438-8400 |
| Symphony | Lotus Development Corp. | S | 617-577-8500 |
| Wingz | Informix Software | S | 800-438-7627 |
| **Business Graphics Programs** | | | |
| Adobe Streamline | Adobe Systems, Inc. | S | 415-961-4400 |
| Arts & Letters | Computer Support Corp. | S | 214-661-8960 |
| Freelance Plus | Lotus Development Corp. | S | 617-577-8500 |
| Graph-in-the-Box | New England Software, Inc. | S | 203-625-0098 |
| Graphwriter | Lotus Development Corp. | S | 617-577-8500 |
| PCARTIST | Aztek | R | 714-770-8406 |
| Picture Perfect | Computer Support Corp. | S | 214-661-8960 |
| **Integrated Software Programs** | | | |
| Enable/OA | Enable Software, Inc. | S | 518-877-8600 |
| Framework III | Ashton-Tate | R | 213-329-8000 |
| INTEGRATED 7 | Mosaic Software | S | 617-491-2434 |
| Microsoft Works | Microsoft Corp. | S | 800-426-9400 |
| PFS:First Choice | Software Publishing | S | 415-962-9002 |
| SmartWare | Informix Software | S | 800-438-7627 |
| Symphony | Lotus | S | 617-577-8500 |
| **CAD Programs** | | | |
| Auto Animator | AutoDesk | S | 415-491-8226 |
| Auto Shade | AutoDesk | R | 415-491-8226 |
| Auto Solid | AutoDesk | R | 415-491-8226 |
| AutoCAD | AutoDesk | R | 415-491-8226 |
| AutoCAD/386 | AutoDesk | R | 415-491-8226 |
| AutoSketch Enhanced | AutoDesk | R | 415-491-8226 |
| Generic CADD | Generic Software, Inc. | S | 206-487-2233 |
| DesignCAD | American Small Business Corp. | S | 205-891-3123 |

* S = supported R = required

# Programs (continued)

| Program | Company | Status* | Telephone |
|---|---|---|---|
| **CAD Programs (continued)** | | | |
| EasyCAD 2 | Evolution Computing | R | 602-967-8633 |
| FastCAD | Evolution Computing | S | 602-967-8633 |
| Personal Designer | Computervision | R | 617-275-1800 |
| VersaCAD | Versacad Corporation | R | 714-960-7720 |
| **Desktop Publishing Programs** | | | |
| FaceLift | Bitstream | S | 800-223-3176 |
| Fontware | Bitstream | S | 800-223-3176 |
| Font Effects | SoftCraft, Inc. | S | 800-351-0500 |
| Freedom of Press | Custom Applications | S | 800-873-4376 |
| GoScript | LaserGo, Inc. | S | 619-450-4600 |
| IBM Interleaf Publisher | Interleaf, Inc. | S | 617-577-9800 |
| SoftType | ZSoft Corporation | S | 404-428-0008 |
| WYSIfonts | SoftCraft, Inc. | S | 800-351-0500 |
| **Database Programs** | | | |
| Advanced Revelation | Revelations Technology | S | 800-262-4747 |
| Clipper | Nantucket Corporation | S | 213-390-7923 |
| CLOUT | Microrim | S | 206-885-2000 |
| dBase IV | Ashton-Tate | S | 213-329-8000 |
| FoxBASE + | Fox Software | S | 419-874-0162 |
| FoxPro | Fox Software | S | 419-874-0162 |
| Paradox | Borland International, Inc. | S | 408-438-8400 |
| Professional Oracle | Oracle Corporation | S | 415-598-8000 |
| R:BASE | Microrim | S | 206-885-2000 |
| **Accounting Programs** | | | |
| A-Plus Tax series | Arthur Anderson & Co. | R | 800-USA-1040 |
| Accounting Ease | Management Info. Services, Inc. | S | 301-879-7178 |
| Advanced Business Accounting Series | Data Pro Accounting Software, Inc. | S | 813-885-9459 |
| DacEasy Accounting | Dac Software, Inc. | S | 214-248-0205 |
| Financial Accounting Pkg. Profit Series | Crosstech System, Inc. | S | 516-932-8020 |
| Job Costing Accounting | Infisy Systems, Inc. | S | 713-820-5954 |
| Networking Accounting System | Dac Software, Inc. | S | 214-248-0205 |
| Pro IV Accountant series | Applications Systems Corp. | S | 714-757-7070 |
| Solomon III series | TLB, Inc. | S | 800-777-0521 |
| **Financial Analysis Programs** | | | |
| Bank Operations Package | Automated Systems, Inc. (SD) | S | 605-335-3636 |
| CAPBUD-Cap. Budgeting Spreadsheet | Computer Handholders, Inc. | S | 215-565-7467 |
| CMO Modeling System | Financial Publishing Co. | S | 617-262-4040 |

* S = supported R = required

# Programs (continued)

| Program | Company | Status* | Telephone |
|---|---|---|---|
| **Financial Analysis Programs (continued)** | | | |
| Financial Tool Kit | Benefit Analysis, Inc. | S | 800-233-3601 |
| Forecast Pro | Business Forecast Systems | S | 617-484-5050 |
| Mortgage Analyser | Sendero Corp. | R | 602-941-8112 |
| **Mathematics** | | | |
| Eureka: The Solver | Borland International, Inc. | S | 408-438-8400 |
| MacroCalc | Anderson Consulting & Software | S | 509-427-5335 |
| MathCAD | MathSOFT | S | 800-MATH CAD |
| 386-MATLAB | Mathworks, Inc. (The) | S | 508-653-1415 |
| Mathematica | Wolfram Research, Inc. | S | 217-398-0700 |
| OPTIMIZATION | Lionheart Press, Inc. | S | 514-933-4918 |
| PC MACSYMA | Symbolics, Inc. | S | 800-MACSYMA |
| **Statistical Analysis Programs** | | | |
| Minitab Statistical Software | Minitab, Inc. | R | 800-448-3555 |
| SAS/Stat | SAS Institute, Inc. | S | 919-677-8000 |
| SPSS/PC + | SPSS, Inc. | S | 312-329-2400 |
| STATGRAPHICS | STSC, Inc. | S | 301-584-5489 |
| Statpro | Penton Software Inc. | S | 800-221-3414 |
| SYSTAT | Systat, Inc. | S | 708-864-5670 |
| **Econometric Modeling** | | | |
| Aremos | WEFA Group | R | 215-667-6000 |
| Econometrics | Lionheart Press, Inc. | S | 514-933-4918 |
| FORECAST! | Syntax Data Systems | S | 714-249-8810 |
| MACRO®WORLD FORECASTER | Black River Systems Corp. | S | 800-841-5398 |
| SIBYL/RUNNER | Applied Decision Systems | S | 617-861-7580 |
| **Engineering Programs** | | | |
| Ansys | Swanson Analysis Systems, Inc. | R | 412-746-3304 |
| Compress | Techdata | S | 713-498-0797 |
| Continuous Beam Analysis | Systek, Inc. | S | 714-734-1351 |
| Global Change Program | Powertronic Systems, Inc. | S | 504-254-0383 |
| Image Mapper | U.S. Mapping | S | 404-498-9697 |
| Micro Hardy Cross | Techdata | S | 713-498-0797 |
| Simulated Solutions Plus | Enfin Software Corp. | S | 619-549-6606 |
| Spice Circuit Simulation Program | California Scientific Software | S | 800-284-8112 |
| Steamnet | FlowNet | S | 606-257-1941 |
| **Scientific Programs** | | | |
| ChemCAD II | Chemstation, Inc. | R | 713-954-4100 |
| IsoMap/Volumetrics | GeoGraphix, Inc. | R | 303-296-0596 |
| MSC/cal | MacNeal-Schwendler Corp | S | 213-259-4999 |
| Molecular Biology Series | Biosoft | S | 201-613-9013 |
| Multispectral Analysis | PCI, Inc. | S | 416-764-0614 |
| Recombinant Toolkit | Biosoft | S | 201-613-9013 |

* S = supported R = required

# Programs (continued)

| Program | Company | Status* | Telephone |
|---|---|---|---|
| Programming | | | |
| 387 BASIC | MicroWay, Inc. | R | 508-746-7341 |
| Borland C++ | Borland International, Inc. | S | 408-438-8400 |
| C Compiler | Lattice, Inc. | S | 800-444-4309 |
| Graphical Kernal System | IBM | S | 800-447-4700 |
| High C | Metaware, Inc. | S | 408-429-6382 |
| Lattice C | Lattice, Inc. | S | 800-444-4309 |
| Let's C | Mark Williams Co. | S | 708-689-2300 |
| Microsoft C | Microsoft Corp. | S | 800-426-9400 |
| Microsoft FORTRAN | Microsoft Corp. | S | 800-426-9400 |
| Microsoft PASCAL | Microsoft Corp. | S | 800-426-9400 |
| Microsoft BASIC | Microsoft Corp. | S | 800-426-9400 |
| NDP FORTRAN 386 | MicroWay, Inc. | R | 508-746-7341 |
| NDP PASCAL | MicroWay, Inc. | R | 508-746-7341 |
| Professional Pascal | Metaware, Inc. | S | 408-429-6382 |
| WATCOM BASIC | Watcom | S | 519-886-3700 |
| WATCOM C | Watcom | S | 519-886-3700 |
| WATCOM COBOL | Watcom | S | 519-886-3700 |
| WATCOM FORTRAN-77/386 | Watcom | S | 519-886-3700 |
| WATCOM PASCAL | Watcom | S | 519-886-3700 |

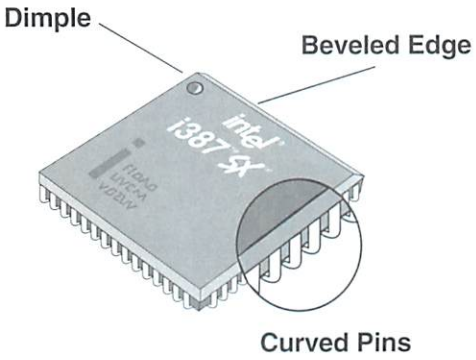
* S = supported R = required

# Installing the Intel387 SX Math CoProcessor

This section explains how to install the Intel387 SX Math CoProcessor in your Intel386 SX-based desktop computer. The Utilities diskette shows a simple animated installation demonstration. You may wish to watch this demonstration before proceeding. (See *Using the Utilities Diskette* for instructions.)

On most desktop computers, your math coprocessor is easy to install and use. Simply refer to your owner's manual and this manual for instructions.

You can identify your Intel387 SX Math CoProcessor by its markings, square shape, beveled edge, dimple, and curved pins.

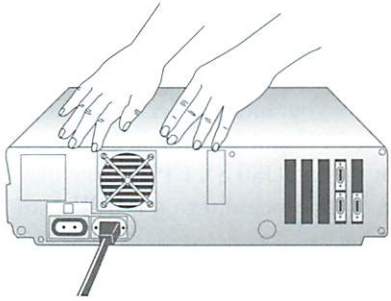



*Because of their small size and high degree of integration, laptop and notebook computers may need special tools and procedures for math coprocessor installation. First check your user's manual to determine if your laptop or notebook computer has a user-accessible math coprocessor socket. If your manual is not clear on this topic, contact your computer dealer or manufacturer for specific instructions for your particular laptop or notebook computer model.*

*If installation sounds complicated, let your dealer install the Intel387 SX Math CoProcessor. If you make a mistake, you could damage the Intel387 SX Math CoProcessor, damage your computer, or injure yourself. If you install it yourself, follow these instructions exactly.*

# 1 Ground yourself and remove cover

Ground yourself by touching the metal back or side panel on your computer (see the illustration below). Unplug the power cord and remove the cover from the computer as described in your owner's manual.



If your computer has math coprocessor installation instructions included in the computer manual, use those instructions as well as the directions in this document.

***Warning: Danger to Equipment!*** *The Intel387 SX Math CoProcessor can be damaged by static discharge. Be sure to ground yourself before handling the Intel387 SX Math CoProcessor by touching the metal on your computer. Limiting your movements during installation reduces static electricity.*

***Warning: Danger to You!*** *Be sure to turn off the computer's power switch and unplug the power cord from the wall outlet. If you don't, you could electrocute yourself.*

# 2 Make sure the Intel387 SX Math CoProcessor is OK

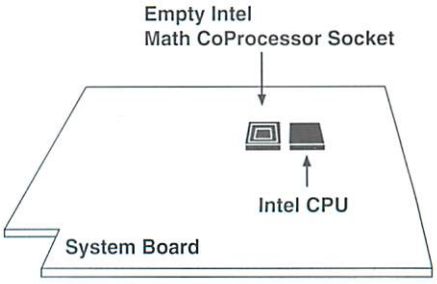
Your Intel387 SX will operate correctly with all Intel386 SX microprocessors, regardless of speed (includes the i386 SX-16, -20, and -25 parts).

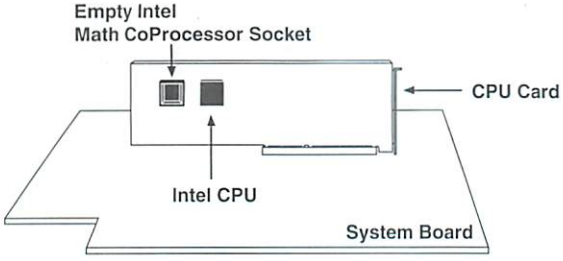
Remove the Intel387 SX Math CoProcessor from its anti-static packing and examine the loop connectors around the edges. Minimize your contact with the metal connectors as much as possible. If you are installing the Intel387 SX Math CoProcessor for the first time, it's very unlikely that

these curved pins will be damaged and it's hard to damage them when you're being careful. However, if any curved pins are damaged, return the Intel387 SX device to your dealer. Do not try to repair damaged curved pins.

## 3 Find the socket

Find the empty socket for your Intel387 SX Math CoProcessor. To do this, locate the Intel386 SX CPU and look for an empty socket nearby that is similar to the one for the Intel386 SX CPU. Note that your Intel386 SX CPU may be on the system board, or on a CPU card (see illustrations below).



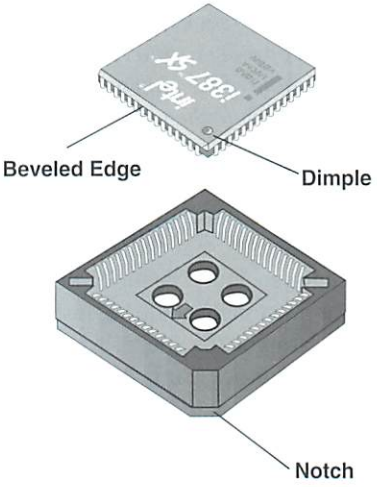

If your Intel387 SX Math CoProcessor socket is on a CPU card, remove the card to install your Intel387 SX Math CoProcessor. Place the CPU card on a flat, static-free surface.

If you cannot locate an empty socket, check your computer user's manual for information or contact the manufacturer of your computer.

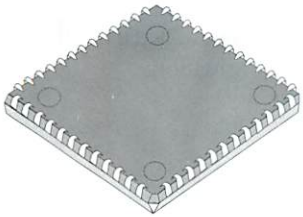
# 4 Find the correct Intel387 SX Math CoProcessor orientation

Match pin 1 on the math coprocessor with pin 1 on the socket. The pin 1 corner of an Intel387 SX Math CoProcessor is marked with a beveled edge and a dimple.

Some sockets label pin 1 with a notch, bevel, dot, arrow, or other mark. If you're not sure where pin 1 is on your socket, first try your computer manual or ask your dealer for help. Please don't guess! *Note that the math coprocessor curved pins on the bottom of the chip must be facing down, into the socket and the Intel logo should be facing up.*



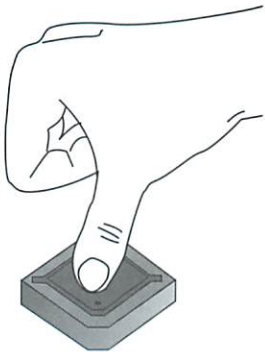

*Be sure to match pin 1 on the math coprocessor with pin 1 in the socket and that the curved pins (curved pins) are pointed into the socket. The Intel logo should be visible after installation. If you insert the math coprocessor the wrong way, the Intel387 SX Math CoProcessor or socket may be damaged.*



The illustration to the left shows the underside of the Intel387 SX Math CoProcessor. This side should face into the socket -- it should **not** be visible after installation.

## 5 Insert the Intel387 SX Chip

After aligning pin 1 correctly, lightly place the math coprocessor chip into its socket. *Note that the math coprocessor curved pins on the bottom of the chip must be facing down, into the socket. The Intel logo should be facing up and readable.* Press firmly and evenly on the Intel387 SX Math CoProcessor to seat the curved pins in the socket. The top of the math coprocessor should be flush with the top of the socket when the math coprocessor is fully inserted.



*Your computer's system board should not bend under the insertion pressure. If it bends more than slightly, see your dealer for assistance. If you require further assistance, call Intel. See the section titled "How to get more information and help" for telephone numbers.*

## 6 Set switches on the system board

You may need to set switches, jumpers, or both on your computer's system board or CPU card to let the computer know you've added a math coprocessor. See your computer's manual for more information.

## 7 Restart your computer

Put the cover back on the system unit. Reconnect all the cables and cords, and plug the power cord into the wall outlet.

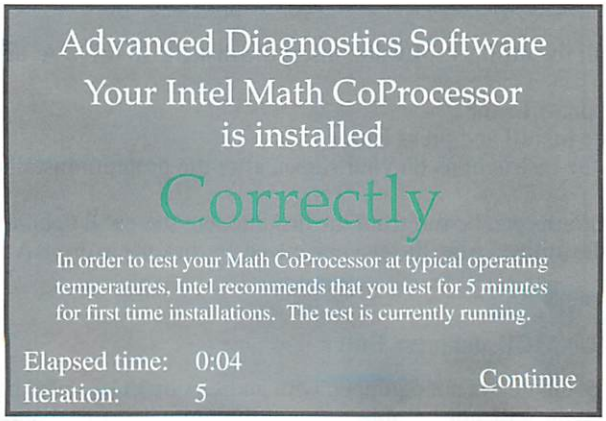
Turn on your computer. If your computer requires it, run the computer's setup or configuration program.

If you have problems with your computer after installing the Intel387 SX Math CoProcessor, turn to *Troubleshooting* in this user's guide.

# 8 Test the Intel387 SX Math CoProcessor in your computer

Your Intel387 SX Math CoProcessor kit contains the Advanced Diagnostics software program which tests the Intel387 SX Math CoProcessor. See *Using the Utilities Diskette* for information on installing and running the test.

When you run the program it should tell you that the Intel387 SX Math CoProcessor is operating correctly (see the screen on this page). If the program tells you that the Intel387 SX Math CoProcessor is not operating correctly, see *Troubleshooting*. If, after checking the items listed in *Troubleshooting*, you still have problems, contact your dealer for assistance. If you require further assistance, call Intel. See *How to Get More Information and Help* for phone numbers.




***Caution:*** *Removing the Intel387 SX Math CoProcessor from its socket is a delicate procedure. If you need to remove your Intel387 SX math chip, call Customer Support. A special extraction tool will be sent to you by express mail. Don't try to remove the Intel387 SX device with ordinary tools; if you do, you might permanently damage the device and/or the socket.*

# Using the Utilities Diskette

Intel includes a set of utilities with your math coprocessor. The Intel Math CoProcessor Utilities diskette contains three utilities: the Quick Installation Overview, the Advanced Diagnostics, and the Personal Productivity Enhancement Demonstration. These utilities provide the following:

1. The *Quick Installation Overview* shows installation is easy and gives you an idea of what the empty upgrade socket looks like.
2. The *Advanced Diagnostics* tests your Intel math coprocessor for proper installation and operation. It also tests all math functions and performs an IEEE standards verification.
3. The *Personal Productivity Enhancement Demonstration* illustrates how your Intel Math CoProcessor increases your personal productivity by speeding up your favorite applications.

To install the utilities software, insert the diskette in drive A and type:

**A:** and press **Enter**
then type **install** and press **Enter**
Follow the instructions on your screen after the program installs.

The programs can be run from the diskette, but they will operate slowly. To run the utilities from the diskette, place the diskette in drive A and type:

**A:** and press **Enter**

Type **RUNMCP** and press **Enter**

If your computer is not equipped with an EGA or VGA video board and display, you will not be able to view the animated installation or the productivity demo because they are graphics based. However, you may run the non-graphics version of the diagnostic tests on any PC display by typing: **MCPDIAG** and pressing **Enter** at the DOS prompt. If your hard disk does not contain enough space for the utilities, or if you don't have 440K of conventional DOS memory available to the program, you will receive an error message.

To run any of these programs under Microsoft Windows, first create a PIF file as described in the *Microsoft Windows User's Guide*. Select "Full Screen" display, with 440KB "required" memory and 512KB of "desired" memory. The "program filename" should be **runmcp.exe**.

If you installed the utilities on your hard disk, you may delete all the files in the **mcpdiag** directory after you test the Intel387 SX. The program **mcpdiag.exe** can be run from diskette at any time to test the Intel387 SX.

*While running the demonstration, press **F1** for help on pausing, or exiting to the DOS prompt. **F10** returns you to the main menu.*

# A Closer Look At Your Intel Math CoProcessor

In this chapter we will examine the Intel Math CoProcessor in greater detail. Although you don't need to read this chapter to install and use your Intel Math CoProcessor, you may want to read this chapter at your leisure to learn more about the history and operation of math coprocessors in general. This chapter covers the following topics:

*Intel Math CoProcessor History*
A brief overview of Intel Math CoProcessor research and development.

*Detecting the Math Coprocessor*
A description of how the software application knows a math coprocessor has been installed.

*Number Representation Overview*
A short review of integers, real numbers, and floating point notation — and why a math coprocessor is superior to a microprocessor in handling floating point calculations.

*Intel Math CoProcessor Operation in Your Computer*
A summary of how the math coprocessor actually improves performance in your computer.

*Benchmark Testing*
A look at math coprocessor benchmark tests and their importance to you.

*The IEEE Standard for Math Coprocessors*
A brief discussion of how standards are employed in your Intel Math CoProcessor.

## Introduction

To understand how your Intel Math CoProcessor speeds up your application software and makes you more productive, we need to briefly examine how the math coprocessor complements and enhances your computer. At the heart of your personal computer is an Intel microprocessor (or Central Processing Unit — "CPU" for short), that is designed to run all general-purpose computing software applications. It handles applications as diverse as word processing, data communications, spreadsheets, Computer Aided Design (CAD), and engineering design and simulation. The CPU is optimized for general purpose computing and integer arithmetic, since the majority of personal computers are used at least part of the time for that type of work.

For application software that requires intense "number crunching" tasks

such as spreadsheets, CAD, program compilation, and mathematical modeling, Intel designed the CPU so that an Intel Math CoProcessor can easily be added, much the way you can add serial ports or memory as you need them. This design allows the CPU to be inexpensive for those who don't need the comprehensive mathematical capabilities.

When an Intel Math CoProcessor is installed in your computer, the CPU sends certain mathematical operations to it. This relieves the CPU from the burden of doing the work, and allows the math coprocessor to do it much faster. In fact, the Intel Math CoProcessor can accelerate application processing speed up to five times, depending on the particular application.

## Intel Math CoProcessor History

When the first 16-bit CPU (the Intel 8086) was being designed by Intel in the late 1970s, we decided that the best way to handle complicated mathematical operations would be to design a separate specialized math processor. There were two reasons for this: first, the demand for extensive number crunching is not as great as for general-purpose computing; second, the integrated circuit technology at the time made it difficult to put the math unit on the same chip as the CPU.

At the same time the Intel 8086 CPU was being developed, a second group of Intel engineers was designing the Intel 8087 Math CoProcessor. The design of the math coprocessor was even more complex than the CPU. The Intel 8087 Math CoProcessor was designed to operate with both the 8086 and the 8088 CPUs. Since then, Intel has introduced a math coprocessor as a companion to each new Intel CPU.

While Intel was designing the 8087 and Intel287™ Math CoProcessors, the IEEE (Institute of Electrical and Electronics Engineers) was developing a standard for all math processors (IEEE 754, discussed later in this chapter). All Intel math coprocessors conform to this standard. The Intel387™ design extends the bus interface to 32 bits to match the Intel386™ CPU. Advanced trigonometric and logarithmic functions were added to the Intel387 DX, Intel387 SX, and Intel487™ SX Math CoProcessors as well.

Application programs written to take advantage of the Intel 8087 and Intel287 Math CoProcessors run without any changes on the Intel387 Math CoProcessor. However, some programs specifically written for the Intel387 Math CoProcessor may not run on older math coprocessors because those programs may use functions not available on the 8087 and Intel287 Math CoProcessors.

The table on the next page summarizes the Intel family of Math CoProcessors, and the CPUs they are designed to complement.

| CPU | Intel Math CoProcessor |
|---|---|
| i486 DX | Built In |
| i486 SX | i487 SX |
| i386 DX | i387 DX |
| i386 SX Desktop | i387 SX |
| i386 SX Portable | i387 SL Mobile |
| i386 SL Portable | i387 SL Mobile |
| i286 | i287 XL |
| 8086 | 8087 |
| 8088 | 8087 |

## Detecting the Math Coprocessor

Once you've installed an Intel Math CoProcessor in your computer, how does the application program know the math coprocessor is present in the computer? Actually, the application can find out about the presence or absence of a math coprocessor in several ways.

The most common way is through the BIOS (the Basic Input/Output System). During the boot-up and power-on initialization, the BIOS tests to see if the math coprocessor is present. Then, when an application is started, it queries the BIOS to determine whether the math coprocessor is present.

The application itself may also test to see if the math coprocessor is there. During initialization of the application, it tests for the math coprocessor in the same way that the BIOS does. It is becoming more common for applications themselves to test for the presence of the math coprocessor and other parameters, and then configure themselves automatically to operate with the hardware that is in your computer.

If no math coprocessor is installed in the computer, the CPU will perform the math calculations using lengthy software instructions that emulate the math coprocessor's built-in functions. The emulation may be within the operating system, but is more likely to be within the application program. When a math coprocessor instruction is encountered, the application executes the emulation subroutine instead. Software emulation performance times are much slower than math coprocessor performance times. This is the primary reason why many CAD programs can't operate without a math coprocessor; their execution speed would be unacceptably slow.

## Number Representation Overview

The key to the Intel Math CoProcessor's ability to provide significant speed increases in mathematical calculations is the way it represents and operates on numbers. The following sections briefly discuss number handling in general.

## Binary Numbers

Computers operate using base two, or binary numbers. That is, there are only two numerals (0 and 1) used to represent all values. We're more accustomed to the decimal system, which has ten numerals, 0 through 9. The binary system is used with computers (and digital electronics in general) because binary values (0 and 1) can be represented by using "off" or "on."

## Integers and Real Numbers

In mathematics, there are several number systems. The two covered here are integers and real numbers. Integers is the set of all whole numbers, both negative and positive, and zero. Thus, there are no fractions. The real number system includes integers and all fractions. For example, integers include 5, 10, -288, 349283; real numbers include 3.89, 0.00000067, -6.666, 14, and 0.

As mentioned in the opening of this chapter, the Intel family of CPUs is optimized to handle integer arithmetic. That is, CPUs are adept at handling and performing mathematical operations on whole numbers (in this case, whole binary numbers). Calculations using real numbers are done using integers to approximate the real values. The math coprocessor, on the other hand, is optimized to handle real numbers.

## Floating Point Representation

The 32-bit word of an Intel386 or Intel486 CPU can represent the integers $-2^{31}$ through $+2^{31}$ (or approximately -2 billion to +2 billion in decimal). The 16-bit word in the Intel286 CPU can represent the values -32,768 through +32,768. In both cases one bit must be used for the sign. These ranges don't cover enough values to be useful in personal computer applications.

To accommodate larger values, multiple precision representation is used. For example, double-precision uses two 32-bit words to represent a single integer value. This results in 63 bits, plus a bit for the sign. Larger values can be handled using multiple words. This does, however, require more CPU time. Arithmetic performed on each word of a multiple precision number can result in a carry (or borrow) which must be added (or subtracted) from the upper word. This can be easily handled in software, but it takes several instructions to do so. Therefore, multiple precision arithmetic takes much longer than single precision.

Math-intensive applications use real numbers, not just integers. Without a math coprocessor, a method must be used to represent real numbers within the capabilities of the CPU's format. To do this, real numbers are scaled so they can be represented as integers. Scaling simply means multiplying an integer by another value.

By adopting scaling, the 32-bit word could be scaled to represent a much larger range of numbers, and could represent real numbers as well as integers. There are limitations that occur when the CPU does arithmetic with scaled, fixed precision integers. For example, if two large 32-bit numbers are multiplied together, the result will be larger than 32 bits, and an overflow occurs resulting in an error. Another error can result when dividing two very large, but nearly equal numbers. The resulting answer becomes too small to represent and an underflow occurs. The third limitation occurs due to rounding errors. These limitations can be avoided by having the CPU read multiple words, however this slows down the computer considerably.

A better way of representing a large range of real numbers is to use scientific notation. Scientific notation is simply a way of scaling values. The scaling factor is always a power of 10, and the number being scaled always has a single digit to the left of the decimal point, so it is not written as an integer. Here are some examples of scientific notation:

| | |
|---|---|
| **$3.2 \times 10^{1}$** | **is 32** |
| **$-6.250 \times 10^{3}$** | **is -6,250** |
| **$2.5 \times 10^{-1}$** | **is .25 (note that $10^{-1}$ is 0.1)** |
| **$3.0 \times 10^{-4}$** | **is .0003** |

The sidebar briefly describes scientific notation, also called *floating point*. Note that in floating point representation, the decimal point "floats" so that it always follows the first digit. This makes it easy to keep track of where it belongs.

## Integer vs. Floating Point

Computers work with two different representations of numbers: Integer numbers and floating point numbers. Integers are "whole" numbers such as 1, 13, and 529. Much of the math used in computer application programs is performed on integers. For example, if you give a spreadsheet the command to "go to line 115" from line 10, the program moves down 105 lines (115 - 10). Lines, of course, are only expressed in whole numbers. On the other hand, other mathematical operations require fractions. Fractions are always represented as decimals rather than as a ratio (such as 1/2).

It's sometimes difficult to work with two numbers that differ greatly in size, such as 1,593.0 and 0.0001. To make it easier, scientific notation was invented. With scientific notation, only one digit precedes the decimal point, and the rest of the digits follow behind the point. This number is then multiplied (or "scaled") by a power of ten. For example, the scientific notation of the two numbers above would be $1.593 \times 10^{3}$ and $1.0 \times 10^{-4}$. The power of ten is always the number of digits that the decimal point has been moved — positive when moving to the left and negative when moving to the right. This notation, using a base number (called the significand) and the power (called the exponent), is also called *floating point* since the decimal point "floats" to the position which leaves one digit to its left.

Computers work with binary numbers rather than the more familiar decimal. Floating-point numbers in binary are represented the same way, except they have a "binary point" instead of a decimal point and they are calculated in base 2, rather than base 10.

With floating point representation, there are three parts to the number:

1. the sign, preceding the number
2. the number to be scaled, called the significand
3. the scaling factor, called the exponent

A 32-bit word can be used to hold the sign, the significand, and the exponent (all in binary), and represents a wide range of real numbers. Double precision extends the range even further.

Floating point representation makes real-number arithmetic easier too. For addition and subtraction the scaled numbers are simply added or subtracted. For example:

$$\begin{array}{ll} & 2.345 \times 10^4 \\ + & 3.227 \times 10^4 \\ \hline = & 5.572 \times 10^4 \end{array}$$

If the exponent is not the same, the significand must be adjusted. To add $4.453 \times 10^5$ and $2.372 \times 10^3$, the second number must be adjusted so its exponent is $10^5$; thus the addition would be:

$$\begin{array}{ll} & 4.453 \times 10^5 \\ + & 0.02372 \times 10^5 \\ \hline = & 4.47672 \times 10^5 \end{array}$$

Scientific notation makes calculations with large numbers simple.

The following example shows how floating point notation makes working with very large or very small numbers (or worse, a combination of the two) simple. Avogadro's Number is an example of a very large number and the intrinsic charge on an electron is an example of a very small number. Avogadro's Number is $6.022 \times 10^{23}$ and the charge on an electron is $1.602 \times 10^{-19}$. Neither of these numbers could "fit" into the CPU without floating point representation; one is too large and the other too small.

To multiply the two together, simply multiply the significand values and add the exponents:

$$\begin{array}{ll} & 6.022 \times 10^{23} \\ \times & 1.602 \times 10^{-19} \\ \hline & 9.647 \times 10^4 \end{array}$$

That's how the computer handles floating point arithmetic, except it uses binary instead of decimal. While this eases the work, it still requires several memory fetches for the CPU and even more for double precision. The CPU actually emulates floating point arithmetic by using multiple registers and multiple instructions to perform a single floating-point-arithmetic operation.

The math coprocessor is designed to eliminate potential problems such as overflow and underflow, and the time-consuming emulation to complete floating-point operations.

First, the internal registers are very large, making overflow and underflow almost impossible. In fact, the internal registers of the math coprocessor can represent numbers as large as $10^{4932}$ to as small as $10^{-4932}$. To put those

into perspective, the larger number is a "1" followed by nearly 5000 zeros, and the smaller number is a decimal point followed by almost 5000 zeros and a "1". These large registers also practically eliminate any problems with rounding.

Second, the math coprocessor's internal operating instructions are written specifically to work with floating-point numbers. Because the microcode is optimized, the math coprocessor executes floating-point arithmetic very quickly.

Finally, the math coprocessor has direct instructions for trigonometric and logarithmic functions. These calculations would require a fairly long algorithm to be calculated by the CPU. That's why programs with trig functions or logarithms show the most substantial improvement with the addition of a math coprocessor. The sidebar outlines the primary Intel Math CoProcessor Functions.

### Intel Math CoProcessor Functions

The Intel Math CoProcessors have six different types of instructions. Three of these types are non-mathematical. These are for moving data, comparing data, and controlling the coprocessor. The other three types of instruction are mathematical.

The first are the **constant** instructions. These allow a mathematical constant, such as 1.0 or Pi, to be quickly retrieved for calculations. The speedy availability of these constants makes calculations requiring them much faster since the constants don't have to be retrieved from memory.

The **non-transcendental** functions are the common mathematical operations. They include addition, subtraction, multiplication, and division, plus square root, absolute value, rounding, and other numerical manipulations.

Finally, the **transcendental** functions allow the math coprocessor to execute trigonometric and logarithmic operations. These include Sine, Cosine, Tangent, plus several base 2 logs and antilogs.

This rich set of mathematical operations allows the math coprocessor to execute many operations with a single instruction that would take many instructions if they were emulated with the CPU.

## Intel Math CoProcessor Operation in Your Computer

Instructions for the math coprocessor differ from those for the CPU. To tell the CPU that a math coprocessor instruction is coming, they are preceded by an ESCape. When the CPU reads an ESCape instruction, it knows that the following instruction and data (if any) are for the math coprocessor.

The CPU then passes the instruction to the math coprocessor. The math coprocessor signals the CPU when it is ready to accept the data. The data, or operand, is either held by the math coprocessor, or is used in an arithmetic operation with a number already in the math coprocessor. When the math coprocessor has all the data it needs, it executes the proper mathematical function by accessing the internal microcode defined by that particular instruction.

The instruction for the math coprocessor doesn't always require data to be fetched. For example, if your spreadsheet cell had the equation SQRT(C4*D2), the math coprocessor would first retrieve the data for cells C4 and D2. It would then multiply them together and hold the result. Next, it would be given the SQRT (square root) instruction. The data for this instruction (the product of C4 and D2) is already held, so it's unnecessary to fetch it from memory. Thus, not only does the specialized SQRT function save a lot of time, but because the data was already held in the math coprocessor, the total calculation takes less time. The CPU, executing this same function, might require many more memory accesses and a great deal more time since it would have to execute an algorithm to calculate the square root.

You might be wondering at this point what the CPU is doing while the math coprocessor is performing this calculation. With many applications, it is briefly waiting for the math coprocessor to finish. However, newer application programs take advantage of this time to execute CPU instructions concurrently. That is, while the math coprocessor is performing its calculations, the CPU continues to execute the application program. If the CPU gets to an instruction that requires the results from the math coprocessor, it has to wait until the math coprocessor is done. In spite of the brief waiting, the CPU/math coprocessor combination will still execute the program faster than the CPU could by itself.

## Benchmark Testing

A benchmark test is a program that exercises a computer and provides a measure of performance. Generally, the performance is measured by the amount of time it takes the computer to completely execute the benchmark test. Good benchmark tests are written to exercise as many different functions of the computer as possible.

Math coprocessor performance can be measured by using either application software benchmarks or floating point benchmark tests. Because end users are concerned with "real-world" performance, application software benchmarks should be looked at more closely. These benchmarks measure performance while running popular applications such as Lotus 123, Microsoft Excel, Borland Quattro Pro, Autodesk AutoCAD, and others.

Application benchmarks most accurately emulate the end-user environment and are the best way to compare test results.

While application benchmark tests can help you select the computer combination that may be best for your application, you might want to run your own benchmark too. You can do this if you haven't yet installed your Intel Math CoProcessor. Select an application program, such as a spreadsheet which has some very complex mathematical expressions — especially transcendental calculations. Then use a stopwatch to measure a particular calculation. After installing your Intel Math CoProcessor run the test again.

Here is a simple spreadsheet example that will show the benefit of having an Intel Math CoProcessor installed in your computer:

1. Open a new worksheet, switch your spreadsheet to manual calculation, and enter the following formula into cell A1:

   @EXP(@RAND)

2. Copy the formula to a large array of cells, such as A1 to Z400.

3. Press F9 to calculate the results.

4. Time the interval until the computer is done (usually when the "WAIT" prompt ends).

The Intel Math CoProcessor reduces the time required for this calculation by about 55%.

## The IEEE Standard for Math CoProcessors

IEEE stands for Institute of Electrical and Electronics Engineers. IEEE standards are specifications for a given piece of hardware or software . Their purpose is to ensure compatibility between computers of different manufacturers. Thus to the consumer, a standard is a very valuable concept. The IEEE and ANSI (American National Standards Institute) sponsor virtually all of the computer-related standards in the United States.

The ANSI/IEEE 754 *Standard For Binary Floating-Point Arithmetic* defines the standards of four basic functions for math coprocessors. First, the standard representation of floating point numbers is defined. Those standards are 64 bits, 53 bits, and 24 bits. The lower-precision standards exist for some older software and certain programming languages.

Next, the rules for rounding and truncating answers are defined. Third, the standard lays down minimum acceptable values for accuracy. And fourth, the data formats that must be accommodated are defined: single length, double length, and extended format for floating point values.

All Intel Math CoProcessors conform to the IEEE 754 standard, ensuring compatibility with all software applications designed to use math coprocessors.

## Conclusion

In this chapter we have taken a more detailed look at how your Intel Math CoProcessor speeds up your application software and increases your productivity. If you would like additional reading material about our math coprocessors or other Intel products, call our Literature Sales Department at 800-548-4725. If you are located outside of the U.S. or Canada, please contact your local Intel sales office.

# Troubleshooting

Read through the symptoms listed below. When you find one that resembles the problem you're having, try the corresponding possible solutions.

***The computer doesn't power on when you turn on the switch, or the operating system prompt doesn't appear on the screen.*** **Check the following:**

- The power cord is plugged into the wall outlet.
- All cables and cords are attached correctly.
- Any boards you removed are reinstalled and properly seated, and reconnected.
- Do the notch and dimple on the Intel387 SX match the notch on the socket or system board? Is the Intel logo visible (facing up)?

***Your Intel Math CoProcessor fails one or more of the Advanced Diagnostic tests.***

- Does your Intel math coprocessor speed equal or exceed your Intel CPU speed? (See page 7 for details).
- Re-check your installation — is the math coprocessor fully inserted? Are the notch and dimple oriented correctly? Is the Intel logo visible (facing up)?
- Did you set the jumpers or system switches correctly, as described in your computer's manual?
- If the math coprocessor still fails a diagnostic test, remove it and return it to your dealer or contact our Customer Support group (see next page).

***Your application programs don't run any faster with a math coprocessor installed.***

- Run the diagnostic tests on the utilities diskette to ensure that your math coprocessor is properly installed.
- If your application has a status screen, check it to see that the program recognizes the Intel387 SX.
- Did you set the jumpers or system switches correctly, as described in your computer's manual?
- Does your application use much floating-point arithmetic? Some applications (such as word processing) don't use floating-point arithmetic. The Intel387 SX can't speed up programs that don't use floating-point arithmetic.

***The Intel387 SX feels hot.***

- It is normal for the Intel387 SX to generate heat while operating.

# How to Get More Information and Help

Here are five easy ways to reach Intel Customer Support.

1 **Call the FaxBACK™ service.**
If you have a touch-tone phone and a fax machine or an Intel FAX board, you can get a copy of anything in our tech support library — the same product and technical information we use ourselves!

| | |
|---|---|
| From inside the U.S. and Canada: | **1-800-525-3019** |
| From Europe: | **+44-793-432509** |
| From anywhere: | **+503-629-7576** |

FaxBACK is available 24 hours a day, every day.

2 **Send a Fax.**

| | |
|---|---|
| From inside the U.S. and Canada: | **1-800-458-6231** |
| From Europe: | **+44-793-431166** |
| From anywhere: | **+503-629-7580** |

3 **Use Your Modem.**
You can use your modem to read these bulletin boards:

| | |
|---|---|
| Intel U.S.A. | **+503-645-6275** |
| Intel Europe: | **+44-793-432955** |
| CompuServe: | **GO INTEL forum** |
| MCI-Mail: | **INTEL SUPPORT** |

4 **Talk to a Customer Support person.**

From inside the U.S. and Canada: **1-800-321-4044**

U.S.A. phone support is available:
Monday through Friday, 7 AM to 5 PM, Pacific time.

| | |
|---|---|
| From Europe - English | **+44-793-431144** |
| From Europe - auf Deutsch | **+44-793-421333** |
| From Europe - en Français | **+44-793-421777** |
| From anywhere: | **+503-629-7000** |

European phone support is available:
Monday through Friday, 08:00 to 17:30.

5 **Send a letter.**
Mail your comments to:

**Intel Customer Support, Mail stop CO3-02**
**5200 NE Elam Young Parkway**
**Hillsboro, Oregon 97124-6497**

# To Order Technical Literature

If you bought the Intel387 SX Math CoProcessor because you want to design hardware that contains it or software that uses it, you'll benefit from the technical literature that Intel can provide.

Call the Intel Literature Department at the following number to order the Intel387 SX literature package: 800-548-4725. Outside the U.S.A. and Canada, call your local Intel sales office.

Be sure to send in your Warranty Registration card. If you do, we can send you important Intel387 SX Math CoProcessor announcements and new product information.

# Limited Lifetime Warranty

Intel warrants to the original owner that the product delivered in this package will be free from defects in material and workmanship. This warranty does not cover the product if it is damaged in the process of being installed or improperly used. Intel recommends you have your dealer install this product.

THE ABOVE WARRANTY IS IN LIEU OF ANY OTHER WARRANTY, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF MERCHANTABILITY, SPECIFICATION, OR SAMPLE. INTEL SHALL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES. INTEL NEITHER ASSUMES NOR AUTHORIZES ANY PERSON TO ASSUME FOR IT ANY OTHER LIABILITY.

If the product is found to be defective, Intel, at its option, will replace or repair the product at no charge except as set forth below, or refund your purchase price provided that you deliver the product, along with proof of purchase (if not registered), either to the dealer from whom you purchased it or to Intel with an explanation of any deficiency. If you ship the product, you must assume the risk of damage or loss in transit. You must use the original container (or the equivalent) and pay the shipping charge.

Intel may replace or repair the product with either new or reconditioned parts, and any part or product replaced becomes Intel's property.

This warranty does not cover replacement of products damaged by abuse, accident, misuse, neglect, alteration, repair, disaster, improper installation, or improper testing.

INTEL SHALL NOT BE HELD LIABLE FOR ANY LOSS OF PROFITS, LOSS OF USE, INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES CAUSED BY THE USE OF THIS PRODUCT OR INABILITY TO USE IT, EVEN IF THE DEALER OR INTEL HAS BEEN ADVISED OF SUCH LIABILITY OR OTHER SPECIAL CLAIMS.

Some states do not allow limitations on how long an implied warranty lasts, so the above limitations may not apply to you. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from state to state.

For warranty information, phone 800-321-4044 or (503) 629-7000.

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